Draft Recovery Plan
for the
Sharpnose (*Notropis oxyrhynchus*) and Smalleye (*N. buccula*) Shiner

November 17, 2020

Sharpnose shiner (*Notropis oxyrhynchus*)

Smalleye shiner (*Notropis buccula*)

Photos: Chad Thomas

U.S. Fish and Wildlife Service
Southwest Region
Arlington Ecological Services Field Office
Arlington, Texas

Executive Summary

The sharpnose shiner (*Notropis oxyrhynchus*) and smalleye shiner (*N. buccula*) were federally listed as endangered (79 FR 45273) with critical habitat (79 FR 45241) on August 4, 2014. The sharpnose shiner historically occurred in the Brazos River, Red River, and Colorado River basins within Texas, where headwaters for these basins lie within the semi-arid High Plains ecoregion. The smalleye shiner historically occurred only in the Brazos River basin. These species are currently restricted to the upper Brazos River and its major tributaries (Figure 1), which represents a greater than 70 percent reduction in range for the sharpnose shiner and a greater than 50 percent range reduction for the smalleye shiner. Throughout much of their historical range, the decline of the sharpnose and smalleye shiners is attributed primarily to habitat loss and modification due to fragmentation and decreased river flow resulting from major water impoundments, drought, and groundwater withdrawals. Water quality degradation, invasive salt cedar, and other factors may have also contributed to their decline. As a result, sharpnose and smalleye shiners' redundancy, or the ability to withstand catastrophic events, is limited to a single population within the historical range. In addition, stream flows within their current range are insufficient during some years to support successful recruitment, such as occurred during the drought of 2011. Given their short lifespan and restricted range, stressors that persist for two or more reproductive seasons (such as a severe drought) severely limit these species' viability, placing them at a high risk of extinction (Service 2018, Executive Summary). A comprehensive account of the species' resource needs, threats, current conditions, and projected future conditions can be found in the *Species Status Assessment Report for the Sharpnose Shiner (Notropis oxyrhynchus) and Smalleye Shiner (N. buccula) Version 2 (Service 2018)*.

The primary purpose of the Endangered Species Act (Act) is the conservation of endangered and threatened species, and the ecosystems on which they depend, so that they no longer need the protective measures of the Act. Section 4(f) of the Act requires the Service to develop and implement recovery plans for listed species. The recovery planning process involves the identification of actions that are necessary to halt or reverse the species' decline by addressing the threats to its survival and recovery. Recovery plans are not regulatory documents; instead they are intended

Figure 1 - Habitat for the smalleye and sharpnose shiner on the Double Mountain Fork of the Brazos River. ***Photo credit: Kevin Mayes, Texas Parks and Wildlife Department.***

to establish goals for long-term conservation of listed species and define criteria that are designed to indicate when the threats facing a species have been removed or reduced to such an extent that the species may no longer need the protections of the Act. There are many paths to accomplishing recovery of a species, and recovery may be achieved without all criteria being fully met. Recovery of a species is a dynamic process requiring adaptive management that may, or may not, fully follow the guidance provided in a recovery plan.

This recovery plan provides a vision, strategy, and criteria to recover the sharpnose and smalleye shiner (Figure 2). The recovery strategy is based on the potential future conditions of the sharpnose and smalleye shiner that are reasonably likely to occur depending on the level of conservation effort and severity of future threats (Service 2018, pp. 65–87). Based on the anticipated future conditions, measurable criteria are designed to indicate when the threats have been removed or reduced to such an extent that the species may be considered for downlisting to threatened status or removal from the Federal List of Endangered and Threatened Wildlife (delisting). Following the downlisting and delisting criteria are more specific recovery actions expected to achieve the recovery objectives. Additionally, a Recovery Implementation Strategy is available that provides additional detail and prioritization of specific tasks for each recovery action. In the final section of the plan, a time and cost estimate for the implementation of the plan is provided. Downlisting these species to threatened status through implementation of recovery actions is estimated to occur in 2040. Recovery is largely based on the establishment of a second resilient population of each species along with achievement of the downlisting criteria (Table 1). The second population should be sustainable, with minimal augmentation (translocations or captive releases) for five generations (10 years). Recovery is estimated to occur by 2050 and cost approximately $71 million.

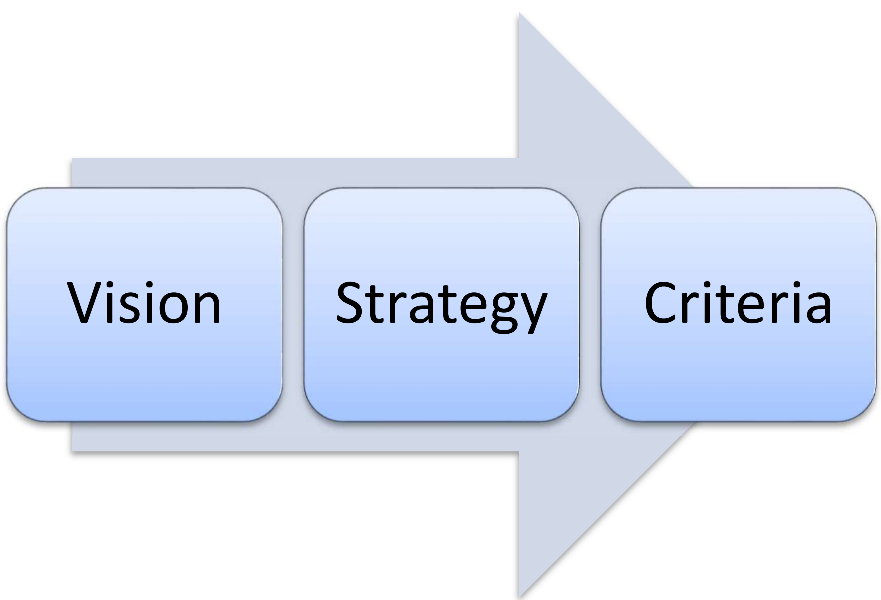

Figure 2 - Three general steps toward recovery planning.

Table 1. Summary of downlisting and delisting objectives and criteria for the smalleye and sharpnose shiner.

Downlisting	**Objectives**	**Criteria**
	1. Improve current population	Ensure that probability of extinction < 10% within 50 years in the existing population and annual reproduction indicates young-of-year in the 3 management units (MUs).
	2. Create captive population	Establish captive population to augment current population.
	3. Ensure adequate streamflow	a) Maintain base flows in the 3 MUs to sustain species for 50 years. b) Ensure recruitment flows within 3 MUs allow for population growth rate necessary for viability.
	4. Improve water quality	a) Maintain water quality parameters below acute and chronic exposure levels in 3 MUs as described in the physiological tolerances section of the SSA. b) Ensure hazardous material spills are avoided or completely contained in 3 MUs over next 50 years. c) Limit new municipal discharge outfalls in 3 MUs to those that meet water quality standards and relocate 25% of existing outfalls outside of Critical Habitat.
	5. Restore river morphology	a) Ensure stream lengths in all 3MUs allow free movement of all life stages b) Maintain or restore stream width and substrate. c) Reduce salt cedar to < 10% of current occupied range
Delisting	6. Ensure presence of two populations	Maintain current population and establish second population within historical range.
	7. Ensure habitat supports both populations	a) Ensure base flows within occupied habitat sufficient for survival rate to achieve Criterion 6. b) Create recruitment flows to generate population growth to achieve Criterion 6. c) Ensure water quality is maintained below acute and chronic exposure levels as described in the SSA within occupied areas to support survival rates to achieve Criterion 6 d) Create quantity and quality of stream morphology for recruitment and survival rates that meet Criterion 6 e) Implement mechanisms to ensure land and water use within occupied habitat will be compatible with species' conservation for foreseeable future.

Acknowledgements

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Recovery Plan for the Sharpnose (*Notropis oxyrhyncus*) and Smalleye (*N. buccula*) Shiner
Date

U.S. Fish and Wildlife Service
Arlington Ecological Services Field Office
Arlington, Texas

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Regional Director Date
Southwest Region
U.S. Fish and Wildlife Service

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Recovery Vision

A recovery vision is an explicit expression of recovery in terms of resiliency (ability of a species to recover from periodic disturbance), redundancy (the number of populations a species has distributed across the landscape), and representation (range of genetic and ecological variation found within a species). It builds upon the description of viability for the species provided in the Species Status Assessment (Service 2018; hereafter, SSA) and defines what recovery looks like for the species.

Population Resiliency

Resilient populations contribute to species viability through redundancy and representation.

Long-term viability of the shiners depends upon maintaining resiliency over time within stream segments capable of accommodating their life history requirements. The viability of both shiner species primarily depends on maintaining the remaining upper Brazos River populations and reintroducing new populations where feasible. The smalleye shiner is believed to have historically occurred only as a single population in the Brazos River. To achieve long-term viability, both species need the population within the upper Brazos to be resilient to stochastic events, representation improved through expanding their ecological diversity, and the sharpnose shiner's lack of redundancy addressed. Increased redundancy for the smalleye shiner within its historical range will be necessary due to ongoing threats to the remaining population.

Our vision of recovery for the sharpnose and smalleye shiners is for each species to have more than a single resilient population across its range that represents the species' genetic diversity and the diversity of habitat types in which the species historically occurred. Long-term viability would require the threats to these species to be reduced to a level whereby the species are no longer in danger of extinction or likely to become endangered in the foreseeable future and can be removed from the Federal List of Endangered and Threatened Wildlife (List).

Recovery Strategy

The following sections present a broad strategy for recovering the sharpnose and smalleye shiner. The purpose of this recovery strategy is to present a recommended approach for achieving the recovery vision. The overall strategy for recovering these species involves restoring and managing watersheds and stream habitat to support resilient populations and implementing captive propagation to support reintroduction within their historical ranges. More specifically, we describe objectives and actions intended to protect and manage water quality, water quantity, and stream conditions and to provide the habitat and resource needs, as well as management of reintroduced populations, necessary for these species to persist.

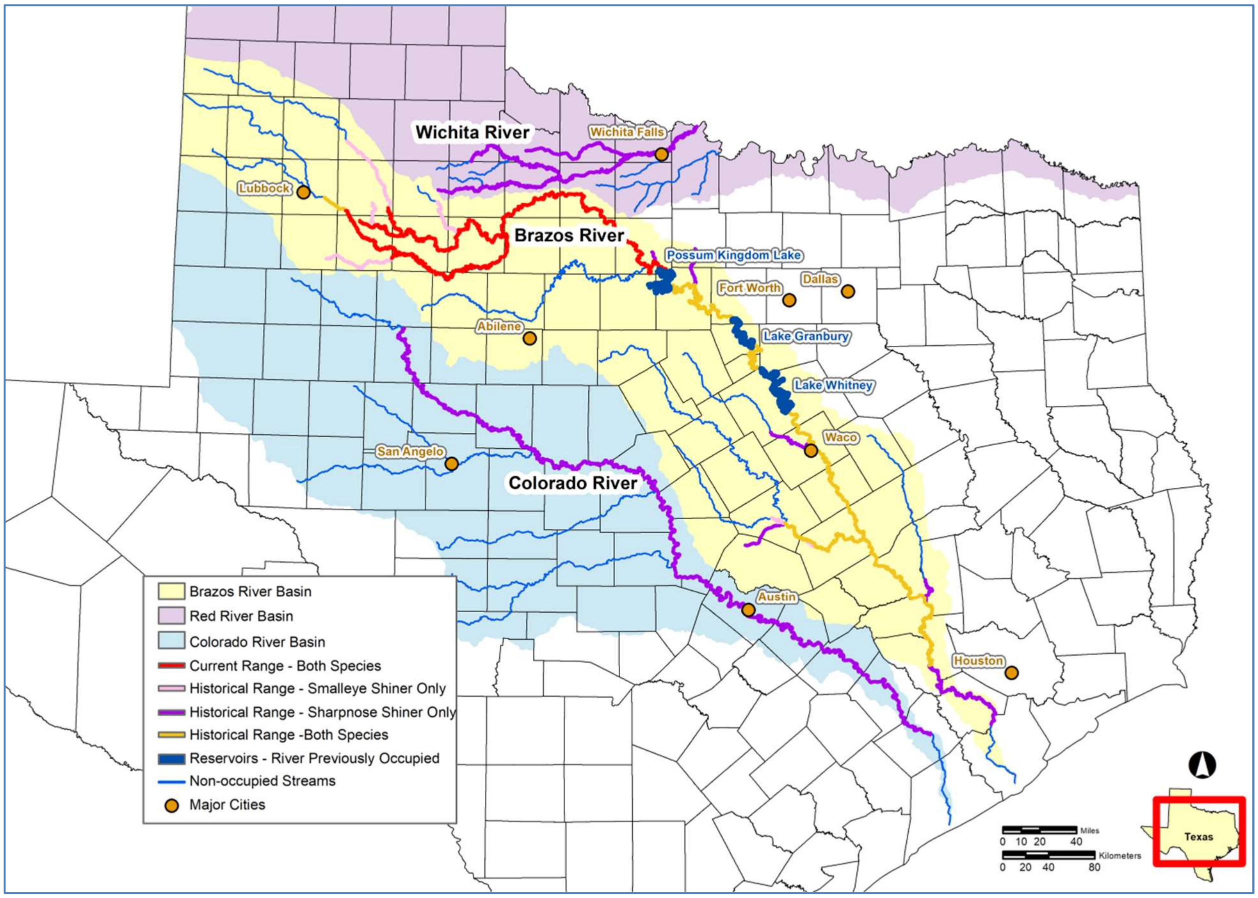

Figure 3 - Historical and current ranges of the sharpnose and smalleye shiner.

Sharpnose shiner was known to historically and naturally inhabit approximately 3,417 km (2,123 mi) of river segments in the Brazos, Red, and Colorado River basins, but now the only sustainable population is restricted to approximately 1,002 km (623 mi) of the upper Brazos River basin, a greater than 70 percent reduction (Figure 3). The smalleye shiner was known to historically and naturally inhabit approximately 2,067 km (1,284 mi) of river segments in the Brazos River basin, but now the only sustainable population is restricted to approximately 1,009 km (627 mi) of the upper Brazos River basin, a greater than 51 percent reduction (Figure 3).

The past and current stressors to the sharpnose and smalleye shiner are associated with habitat loss primarily related to the construction of dams and impoundments which both alter streamflows and reduce unobstructed stream lengths. Additional sources of habitat loss include groundwater withdrawals, climate change and drought, invasive salt cedar (*Tamarix* spp.), desalinization, water quality degradation, and instream gravel mining and dredging. These stressors are discussed in detail within Chapters 3 and 4 of the SSA (Service 2018). As a result, the smalleye and sharpnose shiners are limited to a single isolated population with reduced resiliency and limited representation due to the inability to disperse downstream. The range reduction and isolation of these species to single populations in the upper Brazos River is displayed in Figure 3.

In our 2014 final listing rule, we determined that the sharpnose and smalleye shiners met the definition of endangered species primarily because of the present or threatened destruction, modification, or curtailment of their habitat or range resulting mainly from impoundments and alterations of natural stream flow. Drought exacerbated by climate change and groundwater withdrawals also acts as a source to reduce stream flows and modify stream habitats. Secondary causes of habitat modifications include water quality degradation and salt cedar encroachment that alters stream channels. Additionally, as population sizes decrease, localized concerns, such as commercial harvesting of individuals, also increase the risk of extinction. These factors may not act independently, but may be acting in unison as combined stressors, which can result in cumulative effects to lower the overall viability of these species. Since listing in 2014, threats from legal commercial harvesting have been eliminated as Texas Parks and Wildlife Department (TPWD) prohibits commercial bait harvest within the critical habitat of the sharpnose and smalleye shiner (Mayes et al. 2019, pp. 327-328).

The recovery strategy for the sharpnose and smalleye shiners involves stemming any further range contraction in the upper Brazos River basin, improving resiliency of these species in the upper Brazos River basin and increasing redundancy and representation of both shiners. Implementing the strategy addresses habitat management (stream length, stream flow, and water quality), monitoring, and captive propagation for augmentation and establishment within specific areas (management units) (Figure 4). Much of the strategy focuses on habitat restoration and preservation, which is predicated on an increased understanding of the relationship of the sharpnose and smalleye shiners' life history requirements within the physical, chemical, and ecological conditions of their environments. Information on these species and their habitats (for example, population dynamics, predation, river fragmentation, alterations in stream flow, and responses to identified threats) is needed to provide for better future science-based management decisions and conservation actions. Implementation of the recovery plan will necessitate adaptive management strategies to use the most up-to-date information as it becomes available.

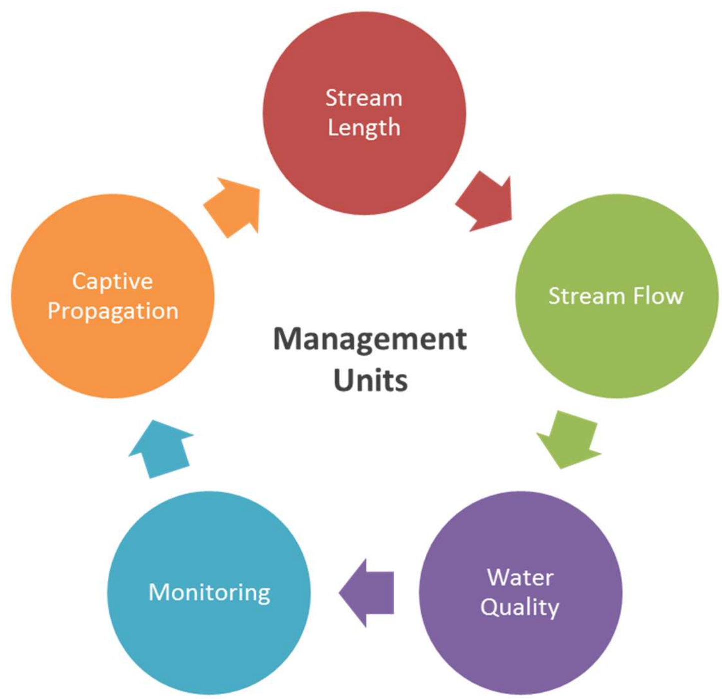

Figure 4 – Basic recovery strategy for the smalleye and sharpnose shiner.

The recovery of the sharpnose and smalleye shiner will involve continued cooperation among Federal, State, and local agencies, private landowners, and other stakeholders. Therefore, the success of the recovery strategy will rely heavily on the implementation of recovery actions conducted by and through coordination with our conservation partners.

Management Units

A management unit is a unit of the listed entity that is geographically or otherwise identifiable and may require different management strategies or other considerations. We divided the currently occupied range into three easily identified management units that provide adequate stream lengths believed to support the life histories of the species: Double Mountain Fork of the Brazos and its tributaries (Double Mountain Fork Unit), Salt Fork of the Brazos and its tributaries (Salt Fork Unit), and the main stem of the Brazos River to Possum Kingdom Reservoir (Main stem Unit, Figure 5). In the SSA, we evaluated additional units for potential reintroduction efforts. One potential reintroduction unit within the historical ranges of both species, the Lower Brazos River Unit (Figure 5), may support the life history requirements for each species. A summary of these river segments can be found in the SSA (Service 2018, pp. 19-25). Other reintroduction units may be identified if additional information suggests stream lengths less than 275 km (171 mi) would support successful reintroductions for either species.

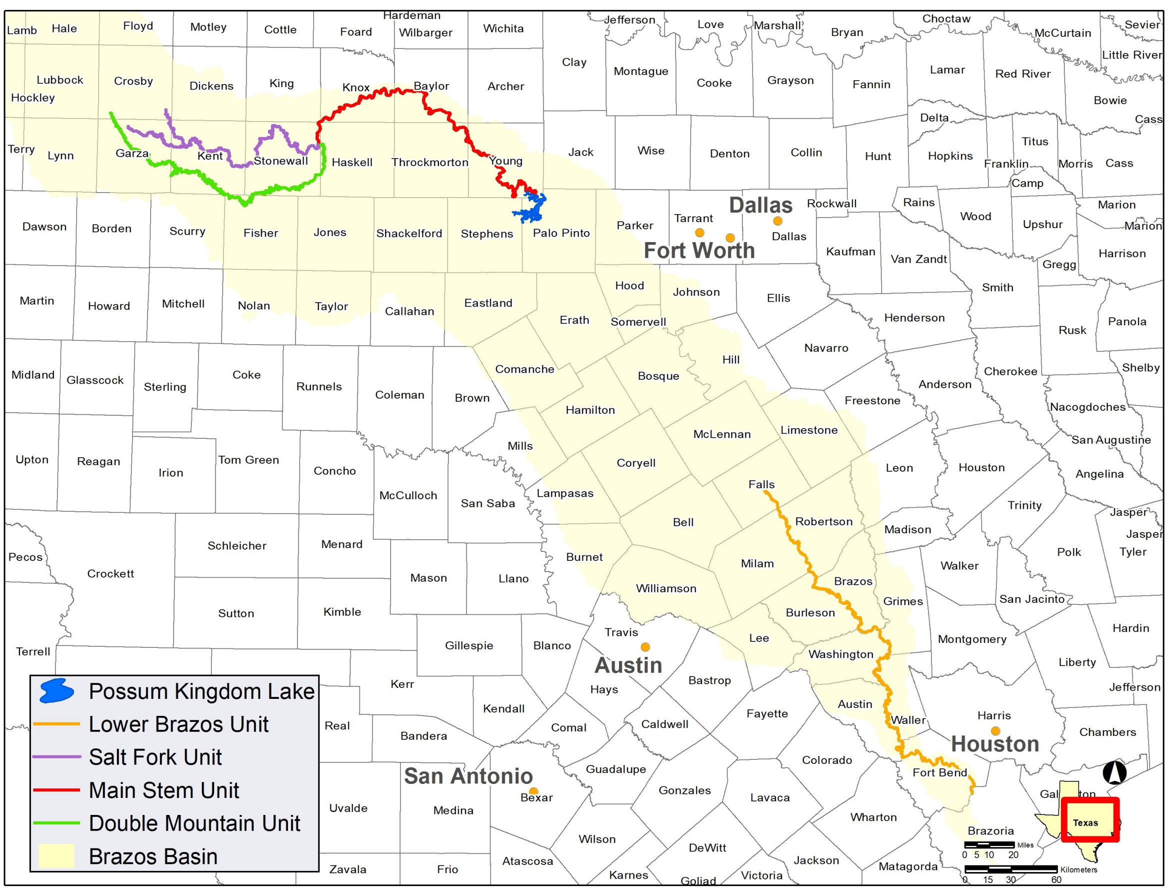

Figure 5 - Management units within the current range and potential reintroduction Lower Brazos river segment for the smalleye shiner and sharpnose shiner.

For recovery planning purposes, we divided the ranges of the sharpnose and smalleye shiner into management units for three reasons. First, the presence of the sharpnose and smalleye shiners in each unit demonstrates reasonable certainty that the population of each species can withstand a catastrophic event in any one management unit. Second, each unit meets the recommended length for long-term survival of these species (Perkin et al. 2010, p. 7). Third, establishing management units across the species' ranges allows for unit-based recovery criteria as stressors and their effects on the species and habitat may not be uniform throughout their range.

Stream Length

As described in *Species Needs, Life History, and Biology* section of the SSA (Service 2018, pp.15–17), stream lengths free of fish passage barriers are, in part, necessary for successful reproduction for both species. Thus, restoration of the upper Brazos River basin to functionally provide the life cycle needs of these species will be an important aspect of recovery. The best available science suggests the primary needs of sharpnose shiner and smalleye shiner populations include anunobstructed, wide, flowing river segment length of greater than 275 km (171 mi) to support development of their early life history stages. Existing partial fish migration barriers such as low-water crossings, road crossings with culverts, and reinforced pipeline crossings can be repaired, removed, or replaced with sturdy, more-permanent structures that are more conducive to fish migration and the passage of flowing water (Figure 6). Existing impoundments that are no longer in service upstream and downstream of occupied areas would ideally be removed, if feasible, to lengthen un-fragmented river segments, provide additional flow, and return the river to a more natural, historical condition. To remove the threat of further stream fragmentation, alternatives to further reservoir development in the upper Brazos River basin capable of fulfilling projected water demand should be identified.

Figure 6 - Partial fish barrier being removed on the Double Mountain Fork. ***Photo credit - Kevin Mayes, Texas Parks and Wildlife Department.***

Stream Flow

The reduction and alteration of stream flow in the upper Brazos River basin is a primary threat to these species, negatively affecting shiner survival and reproduction. Therefore, measures to protect and promote streamflow and seasonal discharge are necessary for the short and long-term viability of these species. Maintaining continual stream flows at adequate levels is important to provide habitat for both species; however, adult sharpnose and smalleye shiners are capable of surviving temporarily in isolated pools with little to no flow, provided water quality conditions remain within their physiological tolerances (e.g., adequate dissolved oxygen) (Ostrand and Wilde 2004, pp. 1329–1338). Based on current life history information, population dynamics modeling estimates a mean summer water discharge of approximately 92 cubic feet per second (cfs) is necessary to sustain populations of sharpnose shiner (Durham 2007, p. 110), while a higher mean discharge of approximately 227 cfs is necessary for smalleye shiner (Durham and Wilde 2009, p. 670). Mean summer water discharge, coupled with pulses of elevated stream flow occurring from April to September that trigger synchronous spawning, are needed for successful recruitment in each species. Alternatives to new reservoir development, water management strategies promoting historical base flow and high flow pulse events, as well as groundwater recharge, are needed to ensure suitable habitat conditions throughout the upper Brazos River basin. Existing impoundments still in use and upstream of occupied areas may be able to provide some benefit to sharpnose and smalleye shiners by adopting water release strategies and management plans to meet instream flow requirements during the spawning season (April–September; Durham and Wilde 2008, p. 533). Ecological restoration of the upper Brazos River would also include salt cedar control by mechanical, chemical, and biocontrol methods to reduce and reverse channel narrowing, promoting wide, shallow channels. Groundwater/surface water conservation and restoration strategies should be implemented to the greatest extent possible to maximize the potential for surface water flows with natural hydrologic characteristics.

The effects of drought on sharpnose and smalleye shiners may be intensified by climate change, land use change, and other human activities on the watershed. A comprehensive upper Brazos River basin drought or water management plan should be developed and implemented to conserve these species and promote sufficient stream flows during periods of drought. The plan should address short-term and long-term approaches that can be used for managing water quantity, water quality, and groundwater use from the upper Brazos River basin under various scenarios of projected climate change. Water releases from reservoirs and reduction of groundwater pumping that is deleterious to the upper Brazos River basin to ensure adequate environmental flows during periods of drought are particularly critical.

Water Quality

Degradation of water quality in the upper Brazos River basin has been identified as a secondary threat to sharpnose shiner and smalleye shiner (79 FR, p. 45275). Significant reduction of water quality results in mortality of individuals and has the potential to affect shiners at the population and species level. The effects of contaminant-related mortality become particularly pronounced during periods of drought and range restriction. The extent of scientific knowledge on water quality needs for the sharpnose and smalleye shiners are summarized in the *Species Needs, Life History, and Biology* and *Influences on Viability* chapters of the SSA (Service 2018). Specifically, point and non-point source pollution from various sources, elevated salinity levels, and toxic golden algae blooms may result in mortality of fish and have the potential to affect these shiners at the population and species level. Sources of water quality degradation include, but are not limited to, the following: (1) desalination facilities, (2) concentrated animal feeding operations, (3) hazardous materials spills, (4) irrigated cropland runoff, (5) municipal and industrial wastewater, (6) golden algae blooms.

Research is needed to better understand the impacts of water quality degradation. Such research will aid in the development of water quality measures that will to help protect shiner habitat from the threat of pollutants or other contaminants in the water. In general, water quality protection measures should either improve or prevent further reduction of water quality of surface water. Sources of petroleum contamination and other pollutants should be identified and steps taken to reduce the likelihood of future contamination. A plan for responding to major spills of hazardous materials and pollutants within the upper Brazos River basin should be developed. The plan should include contingencies to minimize the effects of a contaminant spill on the shiner population through fish collection targets and protocols needed to “rescue” individuals in response to a contaminant spill. The control of golden algae blooms may not be feasible, because current information indicates salinity is a key factor in the timing, location, and toxicity of blooms. Highly saline conditions are a natural occurrence in the upper Brazos River basin, suggesting golden algae blooms will be difficult to manage.

Monitoring

A long-term monitoring program should be developed and implemented throughout these species’ occupied range. Shiner populations should be regularly monitored (surveyed) to help guide and evaluate species conservation efforts as well as the impact of new or on-going threats. Surveys (Figure 7) provide valuable trend information that can signal the need for management actions or more active stream management. Therefore, if it has been shown through monitoring that a portion of the population in a particular management unit is declining, management decisions for these sites can be more informed and effective. Monitoring for the sharpnose and smalleye shiners should focus on population parameters such as, but not limited to: genetic composition, abundance, density, distribution, age class structure, and annual

Figure 7 - Smalleye shiner collected during a survey. ***Photo credit – Clint Robertson, Texas Parks and Wildlife Department.***

reproduction. Monitoring these shiner population parameters will help us annually track progress in achieving the *resiliency*, *representation*, and *redundancy* necessary for recovery, as well as evaluate whether the recovery strategy is effective and progress toward recovery is occurring as predicted.

Captive Propagation and Reintroduction

Captive propagation of sharpnose and smalleye shiners and their reintroduction into currently and historically occupied stream reaches may increase redundancy of these species and protect against catastrophic events impacting the existing population. Captive propagation techniques have been successfully implemented in other similar broadcast-spawning species. Translocation may be an additional option for reintroduction efforts. Research is needed to develop the techniques and requirements to sustain a genetically diverse captive-bred population for these species. Fish reared in captivity can be used to supplement the remaining populations of these species in the upper Brazos River basin following years when conditions are not favorable to successful reproduction. Reared fish can also be used to reintroduce the species in historically occupied river reaches. Based on the best available science, the known historical river reaches do not meet the habitat requirements to indefinitely support a viable, successfully reproductive population; however, captive-bred fish re-introduced into the historical range may be self-sustaining for several years and could act as an *in-situ* redundant population to protect against extinction events in the upper Brazos River basin. Information learned from monitoring reintroduced populations could also confirm or modify estimates of the minimum stream length and instream flow regime requirements necessary to sustain resilient populations of these species.

Recovery Criteria

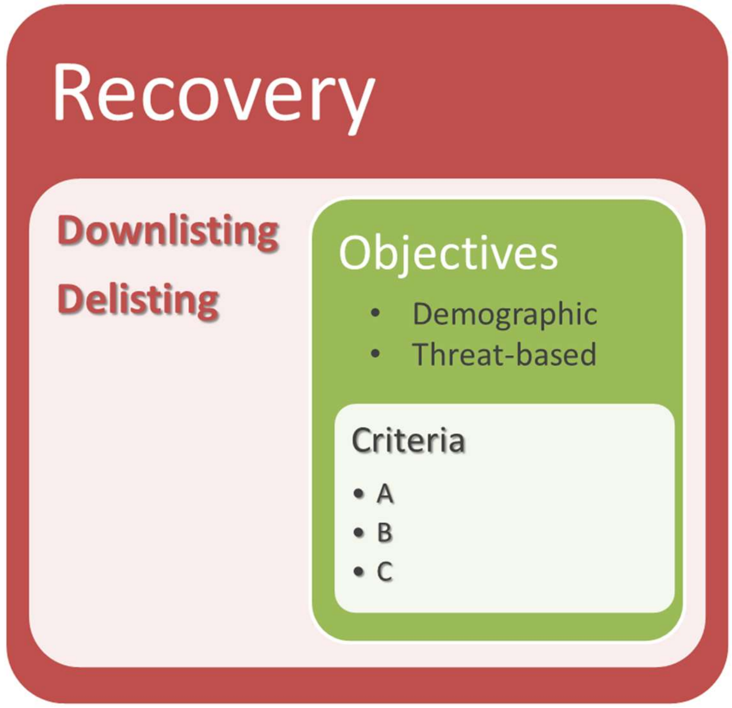

Figure 8 - Recovery plan general organization.

The strategies described above should be used to achieve the recovery vision for the sharpnose and smalleye shiner. Recovery criteria are those objective, measurable criteria that provide a trigger to review a species' status under the Act. The criteria of this plan provide a basis for consideration of the species for downlisting (reclassification to threatened status) and delisting (removal from the List). In the following, recovery criteria are divided into two sets: those pertaining to demographics, and those that address the alleviation of threats (Figure 8). Because these species are currently reduced to a single population with multiple stressors affecting their habitat, recovery is likely to be a long-term, challenging process; therefore, an intermediate goal for this plan is to improve the status of these species to the point that they could be reclassified from endangered to threatened. A threatened species is a species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range. **Reclassification to threatened status will be possible when the ongoing threats within the occupied streams are removed or reduced to the point where a stable population is present throughout suitable habitat in the three management units in the Upper Brazos basin and the only existing threats are expected within the foreseeable future.**

The following criteria will be used to indicate whether downlisting and delisting should be considered. The criteria will be achieved by reducing or removing threats to the species' habitat and conserving or establishing resilient populations throughout the species' range, as determined by monitoring of demographic parameters. Information on the demographic parameters and stream habitat requirements referenced in the following criteria can be found in the SSA (Service 2018).

Downlisting Criteria Demographic	
Objective 1	Improve resiliency of the self-sustaining population of sharpnose and smalleye shiner dispersed throughout the upper Brazos River basin (protect resiliency and representation).
Criterion 1	Population of both species appears stable throughout suitable habitat in the Salt Fork, Double Mountain Fork, and Main Stem management units. Populations will be considered stable when the following demographic and genetic conditions exist: monitoring data demonstrate that (a) the probability of extinction in the wild of less than 10% within 50 years, (b) annual reproduction in the upper Brazos River basin as indicated by the presence of young-of-year within each management unit for at least five consecutive years.
Objective 2	Establish a captive population sufficient to protect against a catastrophic loss and facilitate population augmentation (redundancy and representation).
Criterion 2	A captive population of both species exists with the appropriate number of individuals, sex, and genetic and age structure to augment upper Brazos River population.
Downlisting Criteria Threat-based	
Objective 3	Ensure adequate stream flows (increase resiliency)
Criterion 3(a)	Base flows within the Salt Fork, Double Mountain Fork, and Main Stem management units of the upper Brazos River basin are sufficient to sustain both species over at least 50 years. Under typical drought conditions, stream flows within the three management units maintain adequate flow necessary for reproductive success.
Criterion 3(b)	Timing (two out of three consecutive years), seasonality (April—September) and volume of recruitment flows (pulse and minimum mean discharge flow) within the Salt Fork, Double Mountain Fork, and Main Stem management units of the upper Brazos River basin allow for population growth rates necessary for species viability.
Objective 4	Ensure water quality (increase resiliency)
Criterion 4(a)	Water quality parameters are maintained below acute and chronic exposure levels (that is, concentrations, durations, and combinations of these) that could have a negative impact on the shiner populations in the Salt Fork, Double Mountain Fork, and Main Stem management units. Negative impacts include direct lethal or sub-lethal effects (such as effects on reproduction, growth, development, or metabolic processes) on individuals or developmental life stages, or indirect effects by affecting the shiner's habitat or prey base. Specific exposure levels will be identified as part of the recovery actions and current information about these levels is included in the physiological tolerances section in the SSA. Long-term commitments are in place to ensure that these protections will continue over at least 50 years.

Criterion 4(b)	Hazardous material spills are avoided or completely contained when occurring within the Salt Fork, Double Mountain Fork, and Main Stem management units. The risk of a catastrophic spill over the next 50 years (a spill capable of extirpating the entire shiner population or management unit) occurring within a drainage or recharge area occupied by the shiners is reduced or aggressively managed to an insignificant level.
Criterion 4(c)	The number of new municipal discharge outfalls located in the Salt Fork, Double Mountain Fork, and Main Stem management units are limited to those that meet water quality standards protective of the species and its habitat. Twenty-five percent of the current outfalls (Figure 9) are relocated to an area outside of Critical Habitat. Prioritization of current outfalls for relocation will be identified as part of the recovery actions.
Objective 5	Restore and preserve natural river morphology (increase resiliency)
Criterion 5(a)	Stream lengths within the Salt Fork, Double Mountain Fork, and Main Stem management units allow for the free movement of all life-stages of both shiners, specifically for up- and downstream migration within and between management units as well as downstream dispersal of eggs and fry.
Criterion 5(b)	Stream widths and substrates necessary for shiner occupation are maintained or restored to optimal conditions for shiner life history requirements.
Criterion 5(c)	Salt cedar infestation is reduced to less than 10 percent of the shiners' occupied range.

Delisting Criteria (in addition to criteria 1-5) **Demographic**	
Objective 6	Ensure two self-sustaining populations of the sharpnose and smalleye shiner occur within their historical ranges, as defined by criteria related to population size, distribution and extinction risk (redundancy and representation)
Criterion 6	A resilient population occurs in the upper Brazos River and a second population established within the historical ranges, both with a probability of extinction in the wild of less than 10percent in 50 years.
Delisting Criteria **Threat-based**	
Objective 7	Ensure habitat is sufficient to support two populations of the sharpnose and smalleye shiner, as defined by criteria related to river base flow (3(a) and 3(b)), water quality (4(a)), and stream morphology (5(a) and 5(b)) (resiliency, redundancy, and representation).
Criterion 7(a)	Base flows within occupied habitat are sufficient to generate survival rates necessary to achieve Criterion 6.
Criterion 7(b)	Recruitment flows are sufficient to generate population growth rates necessary to achieve Criterion 6.

Criterion 7(c)	Water quality within occupied areas and reintroduction sites is high enough to support survival rates necessary to achieve Criterion 6.
Criterion 7(d)	Stream morphology is of sufficient quantity and quality to generate recruitment and survival rates that meet Criterion 6.
Criterion 7(e)	Mechanisms exist to ensure that land and water use activities within occupied habitat will be compatible with these species' conservation for the foreseeable future. Such mechanisms could include, but are not necessarily limited to, conservation agreements, conservation easements, land acquisition, and habitat conservation plans.

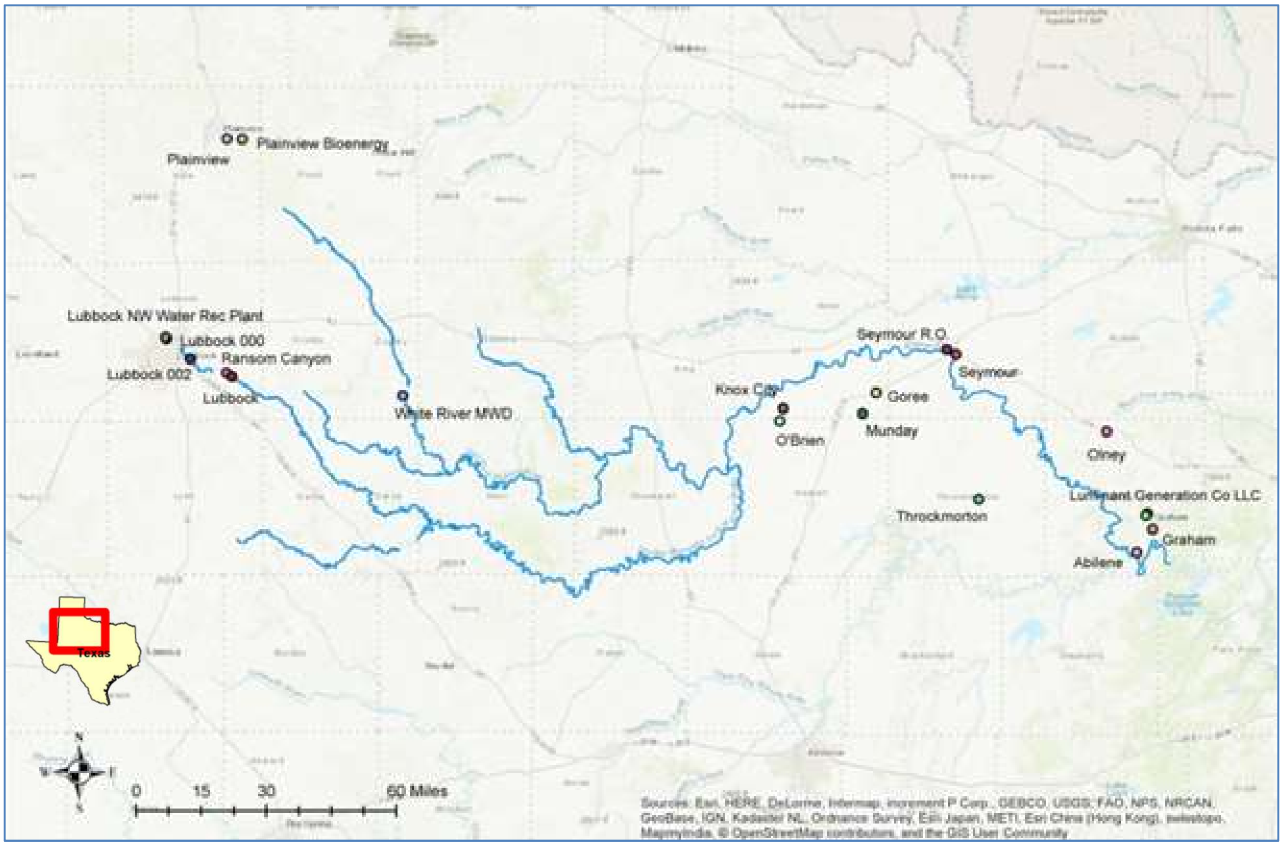

Figure 9 – Texas Commission on Environmental Quality (TCEQ) permitted wastewater discharges located on the upper Brazos River basin and tributaries. Map Credit: Marty Kelly, TPWD.

Recovery Actions

This section provides a broad framework of the site-specific, partner-specific activities that are expected to achieve recovery. Implementation of the recovery actions will involve participation from the State, Federal agencies, non-federal landowners, non-governmental organizations, academia, and the public. The actual on-the-ground activities or specific tasks will be included in a separate Recovery Implementation Strategy (RIS). The RIS is intended to be an adaptable operational plan stepped-down from recovery plan actions. We intend to develop the action plan and specific activities with our conservation partners to design tasks that are feasible and effective and take our partners' interests and abilities into consideration.

The actions described below apply to both species. Implementation of this recovery plan is voluntary and dependent on the cooperation and commitment of numerous partners in conservation.

The actions needed to meet recovery criteria are organized below into five categories that are ranked in order of urgency: (1) ensure adequate stream flows, (2) restore and preserve natural river morphology, (3) maintain current populations of both species, (4) establish captive breeding programs, and (5) ensure water quality. These rankings are primarily based on our assessment of the scope, magnitude, and imminence of the threats impacting the sharpnose and smalleye shiners as described in the SSA (Service 2018). Actions that address threats of higher magnitude and scope are considered more urgent compared to other actions. While this ranking will guide where we proactively focus our attention in the recovery process, it does not imply that these actions are restricted to being completed in this particular order. For example, opportunities to address lower priority tasks will be considered if they arise before higher priority actions are completed.

Recovery Actions

1.0	**Ensure adequate stream flows**	
1.1	**Preclude the need for new reservoir development within the upper Brazos River basin**	Strengthen work with stakeholders to identify alternatives to new reservoir construction to meet future water demands.
1.2	**Research stream flows within the upper Brazos River basin**	Additional information is needed to evaluate stream flows in the upper Brazos River basin and refine estimates of flow regimes necessary to sustain sharpnose and smalleye shiners and their habitat. This will involve monitoring aquifer levels and stream flows under normal and drought conditions and modeling the impact of climate change and water development on aquifer levels and stream flows in the foreseeable future (50 years).
1.3	**Develop and implement measures to retain and promote adequate stream flows**	To protect sharpnose and smalleye shiner habitat, a comprehensive approach to management in the upper Brazos River basin would be beneficial in protecting water quantity. This would involve supporting and working with stakeholders to implement groundwater and surface water conservation and restoration strategies in the upper Brazos River basin to maximize natural surface water flow regimes. It would also include implementing water release strategies to aid fish reproduction and recruitment during the spawning season and base flows throughout the year.
2.0	**Restore and preserve natural river morphology**	

2.1	**Fish passage barrier remediation (≈80% of crossings)**	Work with the Service's Fisheries Program, TPWD, and other knowledgeable entities to determine what types of private road crossings are best designed to allow for water and fish passage and are stable in arid prairie streams. Once a preferred structure is determined, work with landowners to replace existing structures with new structures (potentially through a cost-share program and the National Fish Passage Program). Work with stakeholders to remove existing fish passage barriers or replace them with structures that accommodate fish migration, and remove impoundments if they are no longer useful or in service. Barrier remediation should be prioritized to achieve the largest net conservation benefit to the species (i.e., increasing available stream length, increasing stream flow and connectivity, etc.)
2.2	**Salt cedar control**	Establish and strengthen partnerships to manage and control salt cedar encroachment along the riparian corridor of occupied areas of the upper Brazos River basin. The Service's Partners for Fish and Wildlife Program, the Natural Resource Conservation Service, TPWD, and the Brazos River Authority (BRA) are four examples of groups implementing salt cedar control projects in the area. Priority areas will likely include riparian corridors along occupied river reaches, particularly the upper Brazos River, Double Mountain Fork of the Brazos River, and North Fork Double Mountain Fork of the Brazos River, where sharpnose and smalleye shiners appear most abundant.
3.0	**Maintain current populations of both species**	
3.1	**Conduct population viability analysis**	Develop a PVA for both species in the upper Brazos River basin to determine probabilities of extinction in 50 years. A PVA for augmentation and reintroduction sites is needed to determine appropriate stocking levels.
3.2	**Monitor Population/distribution**	Develop and implement an annual monitoring program that establishes standardized protocols and sampling frequencies in order to monitor trends in abundance, distribution, and demographic structure of sharpnose and smalleye shiner populations.
3.3	**Research stream length and flow requirements**	Continued research on stream length and required instream flow regimes is necessary for species' survival, reproduction, and recruitment.
3.4	**Develop and implement genetic management plan**	Develop and implement a management plan that identifies and protects genetically unique population segments across the inhabited range for both species.
3.5	**Control non-native/Invasive aquatic species**	Develop and implement public outreach and monitoring programs to remediate the presence of non-native/invasive aquatic species (e.g. gulf killifish) in the upper Brazos River basin.
4.0	**Establish captive breeding program**	
4.1	**Develop a comprehensive sharpnose and smalleye shiner captive**	A comprehensive CPCP should be developed to guide captive maintenance and breeding programs and a reintroduction strategy for both species. The goal of the captive propagation portion of the CPCP will be to outline the steps necessary to provide a

	propagation and contingency plan (CPCP) consistent with the Service's Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act	representation of the genetic characteristics of the wild populations should reintroduction be necessary. The contingency portion of the CPCP also will establish the collection targets and protocols needed to respond to crisis situations. Contingency planning should not be delayed until the completion of genetic, breeding, and reintroduction studies, but should be updated as these studies are completed. The CPCP should be developed in coordination with agencies that would likely be involved with the collection efforts, including TPWD, Service, and experts from academic institutions with expertise in determining collection levels that will represent enough genetic diversity to keep the species viable. Identifying facilities suitable for captive propagation and contingency portions of the CPCP is necessary for its success. Institutions involved in collection efforts would need to hold appropriate state and Federal permits. For each facility, a Participation Plan should be developed in coordination with the Service that outlines the level of commitment to cooperate (long-term versus short-term holding facilities), qualified personnel to collect and transport animals, research to be conducted, and level of information to be collected. The CPCP and Participation Plans should be periodically re-assessed (for example, annually) and altered as necessary.
4.2	**Establish and maintain captive breeding programs for sharpnose and smalleye shiners**	A captive population of both species would serve as refugia, population augmentation, and possible reintroduction sources. Captive propagation of sharpnose and smalleye shiners, and their reintroduction into currently and historically occupied stream reaches, may be the only way to address the lack of redundancy these species currently display. The number of individuals in captivity and effectiveness of the captive breeding program should be monitored. Captive shiner populations should be monitored closely for disease and other health concerns. If reintroduction is deemed necessary, precautions should be taken to ensure the individuals to be introduced are free from disease or other harmful agents into the wild. Commitments to long-term management of these captive populations are needed. Biological information on the species should be collected in captivity, particularly information on reproduction and early life stages.
4.3	**Develop reintroduction plan**	Develop and implement a plan that outlines parameters for the release of captive-bred individuals into currently and historically occupied stream reaches.
5.0	**Ensure water quality**	
5.1	**Evaluate and establish water quality standards necessary for protection and recovery**	Discharges from industrial sites, wastewater treatment plants, flood channels, and mining sites, runoff from feedlots and grazing land, return flows from agriculture, and other sources are not well understood and should be investigated. Toxicity studies should be conducted to determine the full range of potential effects of pollutants and contaminants. Target or threshold levels of water quality constituents needed to ensure long-term protection of the

		species should also be identified. The information collected through the implementation of this recovery action should be used in comparison to water quality monitoring data to help determine when water quality degradation has occurred or if the water quality of occupied sites is adequate to sustain the populations of each shiner species in their habitat.
5.2	**Formulate best management practices for water quality protection from point and non-point source pollution**	Strengthen work with stakeholders to determine the source of pollution discharges negatively affecting the shiners and to take steps to avoid and minimize future surface water contamination. Plans should be developed to avoid, if possible, or contain and remediate catastrophic spills within the watersheds occupied by these species.
5.3	**Limit and relocate new and existing municipal outfalls located in Critical Habitat**	Limit the number of new municipal discharge outfalls located in the Salt Fork, Double Mountain Fork, and Main Stem management units to those that meet water quality standards protective of the species and its habitat. Relocate 25% of existing outfalls to an area outside of Critical Habitat. Prioritize current outfalls for relocation.

Time and Cost Estimates

Presented below is a table of recovery actions and their estimated time and costs of implementation (Table 2). The estimated time and costs for the site-specific, partner-specific activities that are expected to achieve recovery will be developed and specified in the Recovery Implementation Strategy. We intend to update the implementation strategy, in coordination with our conservation partners, as frequently as needed by incorporating new pertinent information.

The time and cost table contains the total estimated cost for the expected duration of the action. Estimated costs include only project-specific contract, staff, or operations costs in excess of base budgets. They do not include budgeted amounts that support ongoing agency staff responsibilities. This recovery plan does not commit the Service or any partners to carry out a particular recovery action or expend the estimated funds.

We expect the status of the sharpnose and smalleye shiners to improve such that we can downlist to threatened status in approximately 20 years. We expect to achieve delisting criteria in approximately 30 years for a total estimated cost of $71,408,000. These timeframes are based on expectation of full funding, implementation as provided for in the recovery plan and implementation strategy, high degree of success in executed actions, and full cooperation of partners.

Table 2. Estimated cost, time, and priority for recovery actions for the sharpnose and smalleye shiner

RECOVERY ACTION	POTENTIAL PARTNERS	ESTIMATED COST/YEAR	ESTIMATED TIME (YEARS)	TOTAL COST	PRIORITY [i]	INFORMS RECOVERY CRITERIA	ADDRESSES THREAT[ii]
1.0 Ensure adequate stream flows							
1.1 Preclude the need for new reservoir development within the upper Brazos River basin	USFWS, TPWD, state partners	$100k	10	$1,000k	1	1, 3(a), 3(b), 5(a), 5(b), 7(a), 7(b), and 7(d)	1,2,3
1.2 Research stream flows within the upper Brazos River basin	U.S. Geological Survey (USGS)	$150k	2	$300k	3	3(a), 3(b), 7(a), 7(b), 7(c), and 7(d)	2,3
1.3 Develop and implement measures to retain and promote adequate stream flows	USFWS, TPWD, academia	$100k	3	$300k	1	3(a), 3(b)	2
2.0 Restore and preserve natural river morphology							
2.1 Fish passage barrier remediation (≈80% of crossings)	USFWS	$200k	15	$3,000k	2	1, 3(a), 3(b), and 5(a)	1
2.2 Control salt cedar	USFWS, TPWD	$500k	20	$10,000k	1	5(a), 5(b), 5(c), 7(a), 7(b), and 7(d)	2
3.0 Maintain a resilient population of both species							
3.1 Conduct population viability analysis	USFWS,USGS	$70k	1	$70k	3	1 and 6	4
3.2 Monitor population/distribution	USFWS, academia	$100k	15	$1,500k	2	1 and 6	4
3.3 Research stream length and flow requirements	USFWS, academia, USGS	$150k	2	$300k	3	3(a), 3(b), 5(a), 7(a), 7(b), and 7(d)	1 and 2
3.4 Develop and implement genetic management plan	USFWS, TPWD, academia	$150k	3	$450k	2	1, 2, and 6	4
3.5 Control non-native/invasive aquatic species	USFWS, TPWD, academia, USGS	$25k	10	$250k	3	1	4

4.0 Establish captive breeding program							
4.1 Develop a comprehensive sharpnose and smalleye shiner captive propagation and contingency plan (CPCP) consistent with the Service's Policy Regarding Controlled Propagation of Species Listed Under the Endangered Species Act	USFWS	$61.5k	2 (Evaluated at least twice for 20 years)	$123k	2	1, 2, and 6	4
4.2 Establish and maintain captive breeding programs for the sharpnose and smalleye shiners	USFWS	$122k	20	$2,440k	1	1, 2, and 6	4
4.3 Develop reintroduction plan	USFWS, state partners	$90k (yr1) + $75k (14yrs)	15	$1,140k	3	2 and 6	4
5.0 Ensure water quality							
5.1 Evaluate and establish water quality standards necessary for protection and recovery	Academia, USGS, USFWS, Environmental Protection Agency (EPA), TCEQ, BRA	$100k	5	$500k	3	4(a), 7(c), and 7(e)	3
5.2 Formulate best management practices for water quality protection from point and non-point source pollution	TPWD, EPA, TCEQ, Railroad Commission of Texas, BRA	$35k	1	$35k	2	4(b) and 7(e)	3
5.3 Limit and relocate new and existing municipal outfalls located in Critical Habitat	USFWS, EPA, TCEQ, TPWD	$10,000k	5	$50,000k	3	4(c) and 7(c)	3

Priority 1– An action that must be taken to prevent extinction or to prevent the species from declining irreversibly. **Priority 2–** An action that must be taken to prevent a significant decline in species population/habitat quality or some other significant negative impact short of extinction. **Priority 3–** All other actions expected to provide for full recovery of the species.

[ii]Threats numbering system: 1) river fragmentation; 2) alteration of natural stream flow regime; 3) water quality degradation; 4) population viability

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